TRIUMF Experiment E614
Technical Note 86.2
GEANT Clustering Methods

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1 Present clustering

According to Konstantin explanation we have now the below GEANT clustering.
1. Average distance between clusters is $140\mu m$.
2. GRID command of the GARFIELD has been used to create a function $t_0^{(1)} = f(x, y)$ where $t_0^{(1)}$ is a travel time of an electron from a point (x,y) of a cell. Runge-Kutta drift method has been used without taking to account any physical processes in a gas and cell.
3. Time spread of each drift electron is $\sigma = 3ns$=const.
4. Signal from a track $A(t)$ is a sum of all electron signals. Each one has zero leading edge and amplitude of $a(t) = +1 = const$. Arrival time t_0 of a track corresponds to a time crossing of a threshold with the signal $A(t)$. Threshold of $1.6e$ for example corresponds to arrival time of 1st electron with probability of 40% or 2nd electron with probability of 60%.
5. Space resolution of a track is $\sigma_d = 100\mu m$=const, where d is a shortest distance between wire and the track.

The above simplest GARFIELD model can be compared with real GARFIELD calculations. The GARFIELD calculates a σ_d with an enough accuracy (see Fig.25 in TN-81). Different methods of STR calculation have been analyzed in M.Deily, N.P.Hessey ATLAS Muon NOTE #002, 16 April 1999. A final results one can see in Fig.1. The different methods compared with a direct measurement of STR using an outside strip detectors with pitch of $5\mu m$. According to Fig.1 the GARFIELD calculates STR with a maximum deviation of $150\mu m$ for the drift tube with $r = 14.8mm$. We have $d_{max} = 2.8mm$ in DC4 and could apply a scaling factor of $2.8/14.8 = 0.19$. It corresponds to a maximum GARFIELD error of $150\mu m \cdot 0.19 = 28\mu m$.

All calculations in this TN have been done using the Signal section of the GARFIELD for DC4 at $B = 2T$. The time spread σ of a single electron because only a diffusion in DC4 has been calculated by GARFIELD as a function of a travel time. One can see the result in Fig.2. A space resolution function σ_d calculated at $\theta = 45°$ by GARFIELD shown in Fig.3. The σ_d has been calculated using the formula $\sigma_d = \sigma_t / f'(d)$. The $f'(d)$ is derivative of a STR function $t = f(d)$. σ_d at $\theta = 0°$ shown in Fig.4. Calculated STR for $\theta = 45°$ and $\theta = 0°$ are presented in Figs.5,6.

One can see a big discrepancy between the present GEANT clustering and results calculated by the same GARFIELD. Time spread of each drift electron is not $\sigma = 3ns$=const. It changes from zero to 100ns. Space resolution of a track is not $\sigma_d = 100\mu m$=const. It changes from $1mm$ to $10\mu m$. Some improvement of the present clustering is needed probably to exclude possible deviations of Michel parameters from correct values even at a good confidence level after a "blind analysis". Two possibilities of an improvement are proposed.

2 Possible improvement of the clustering

1. Average distance between clusters is $140\mu m$.
2. GRID command of the GARFIELD has been used to create a function $t_0^{(1)} = f(x, y)$ where t_0^1 is a travel time of an electron from a point (x,y) of a cell. Runge-Kutta drift method has been used without taking to account any physical processes in a gas and cell.
3. Time spread of each drift electron is the function from Fig.2.
4. Signal from a track $A(t)$ is a sum of all electron signals. Each one has zero leading edge and amplitude of $a(t) = +1 = const$. Arrival time $t_0^{(2)}$ of a track corresponds to a time crossing of a threshold with the signal $A(t)$. Threshold of $1.6e$ for example corresponds to arrival time of 1st electron with probability of 40% or 2nd electron with probability of 60%.
5. The time $t_0^{(2)}$ is smeared with the function from Fig.7 to have a correct value t_0 of the arrival time (details see below).
6. A time resolution $\sigma(t)$ of the track is the function from Fig.8 (details see below).
7. A space resolution σ_d of the track is calculating along the shortest distance vector $\vec{d}$ using $t_0^{(1)} = f(x, y)$ table and $\sigma(t)$.

Let me describe the above procedure:
• A diffusion spreads an electron drift time in a chamber.
• An attachment, a gain spread, ions movement from a signal wire, a cluster structure, a noise, a preamp shape spreads a total signal also.
• Therefore a spread of an electron drift time in the DC4 at B=0 has been calculated taking to account a diffusion influence only (Fig.2). After that a track time resolution has been calculated taking to account all processes and excluding a diffusion (Fig.7). A total time of a track resolution taking to account all processes in the DC4 is presented in Fig.8.

The above procedure can provide probably a better approximation of a real STR and resolution because a time resolution $\sigma(t)$ is really a function of t, θ, ϕ where θ and ϕ are angles between a wire and a straight track (see TN-86). According to TN-86 a $\sigma(t)$ spread from θ and ϕ does not reach 5 times. An improvement is possible only for an aligned detector. A misalignment can break all above speculations.

Figs.3-6 could be the base for comparison of GEANT clustering and GARFIELD results.

3 GEANT without clustering

STR and time resolution in DC4 at B=2T have been calculated in TN-86. Calculations done for straight tracks with shortest distance step of $\Delta d = 100 \mu m$, and angle steps of $\Delta\theta = 5^\circ$ and $\Delta\phi = 5^\circ$ (see TN-86). The files from the TN-86 could serve as a base for creation functions $d = f(t, \theta, \phi)$ and $\sigma_d = f(t, \theta, \phi)$ for a track reconstruction.

Disadvantage of the proposed method (many people use this method) is some errors for tracks with a radius R about a few cell size at a small longitudinal momentum p_l of a positron. Seems to me this error is not so big because $R = 30mm$ at $E_e = 20MeV$. Next disadvantage is a some error about $30\mu m$ of GARFIELD's STR calculation. STR calculation using the "unfolding method" (see ATLAS Muon NOTE #002, 16 April 1999) could eliminate this error about in 5 times. The ATLAS Muon NOTE is attached.

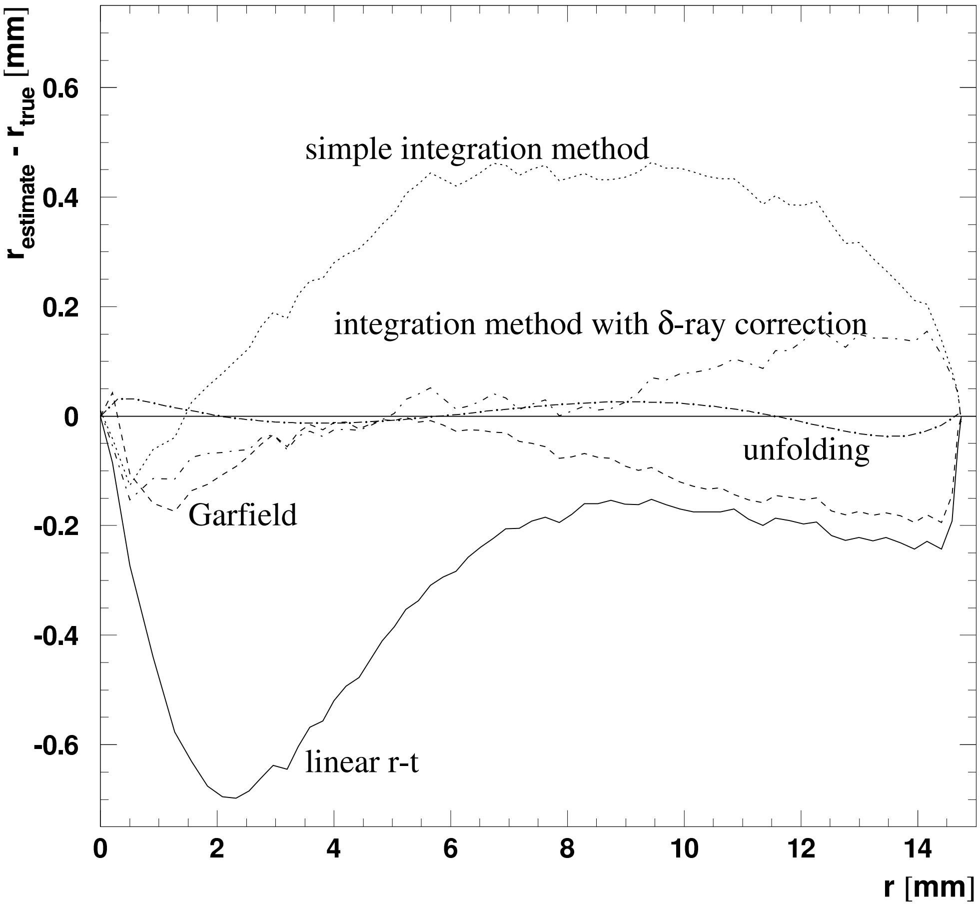

Figure 1: Comparison of the accuracies of all described methods for obtaining a first order $r-t$ relationship. Horizontal zero line corresponds to a direct STR measurement with outside strip detectors. It is Fig.11 from the ATLAS Muon NOTE.

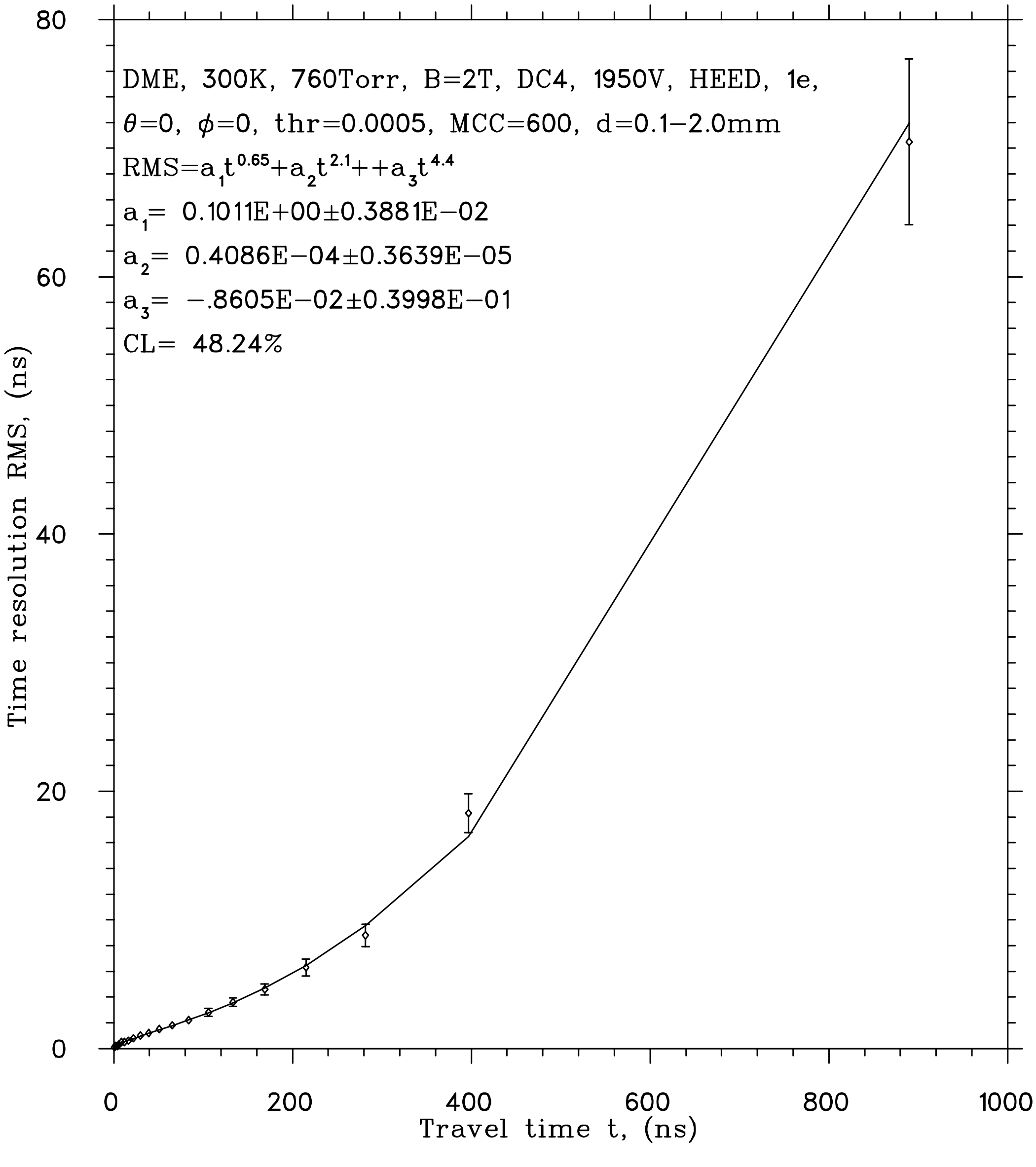

Figure 2: Time spread of single electron in DC4 at B=2T at $\theta = 0°$. Diffusion only is included.

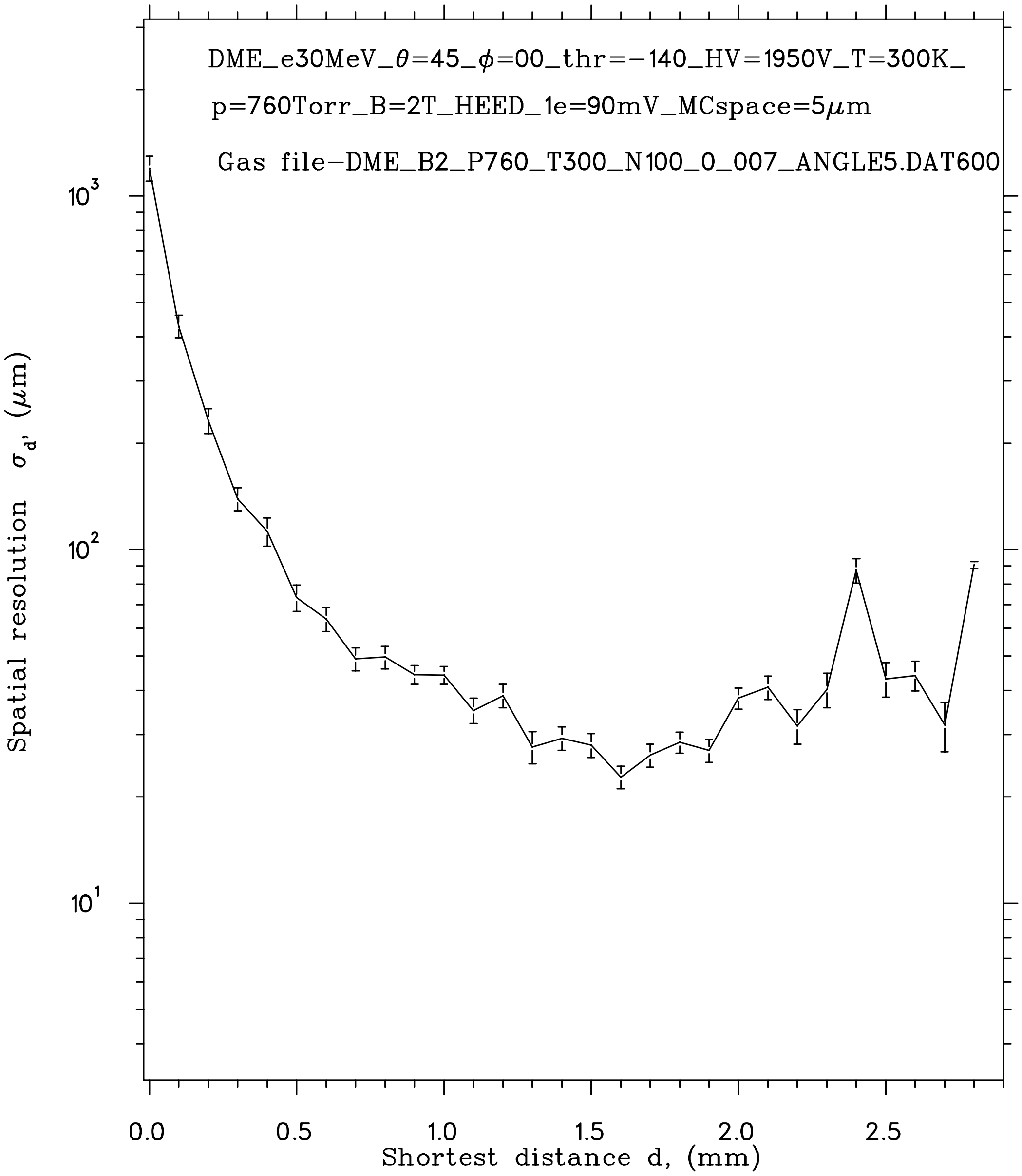

Figure 3: Space resolution of DC4 at B=2T at $\theta = 45°$.

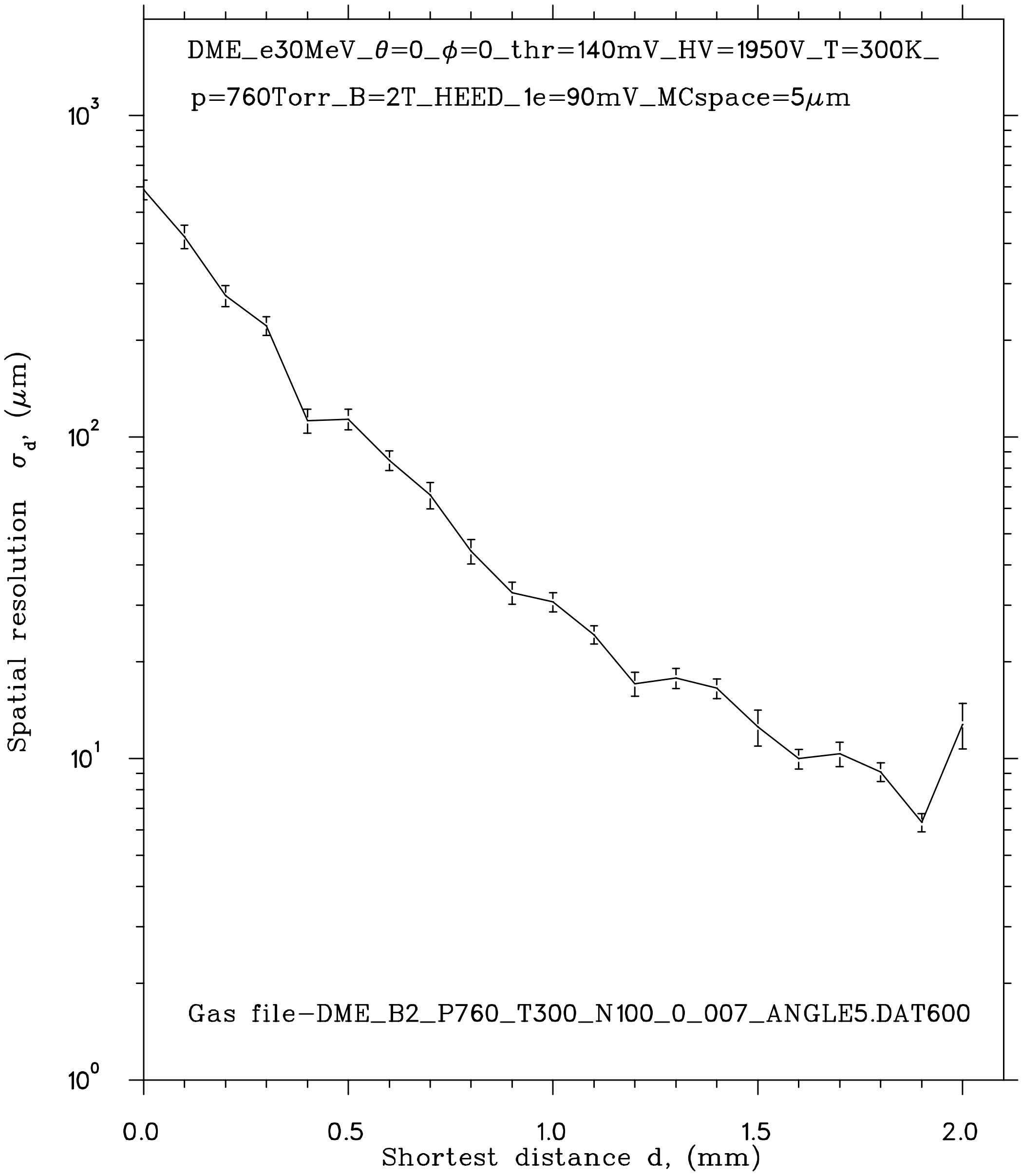

Figure 4: Space resolution of DC4 at B=2T at $\theta = 0°$.

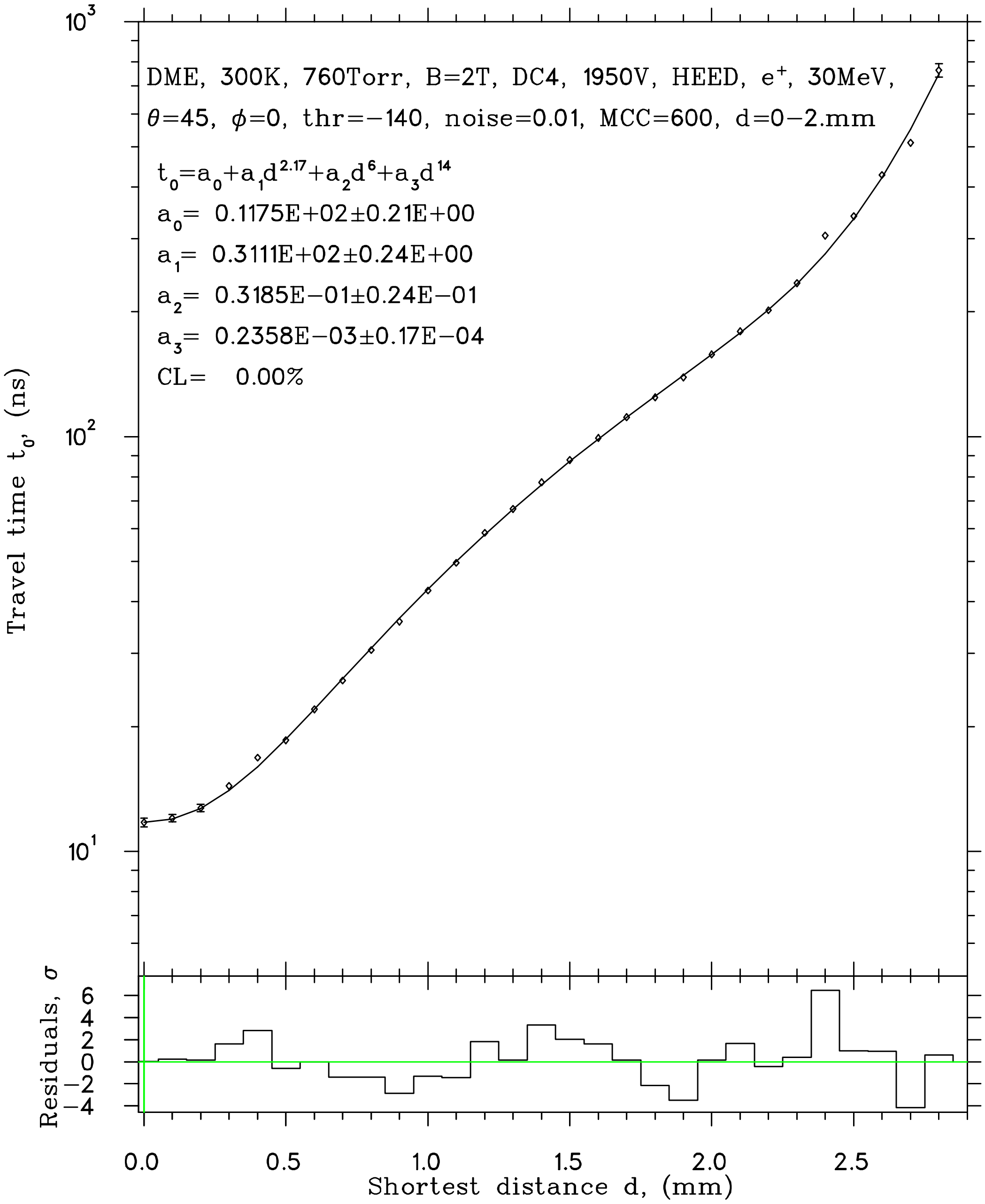

Figure 5: STR of DC4 at B=2T at $\theta = 45°$.

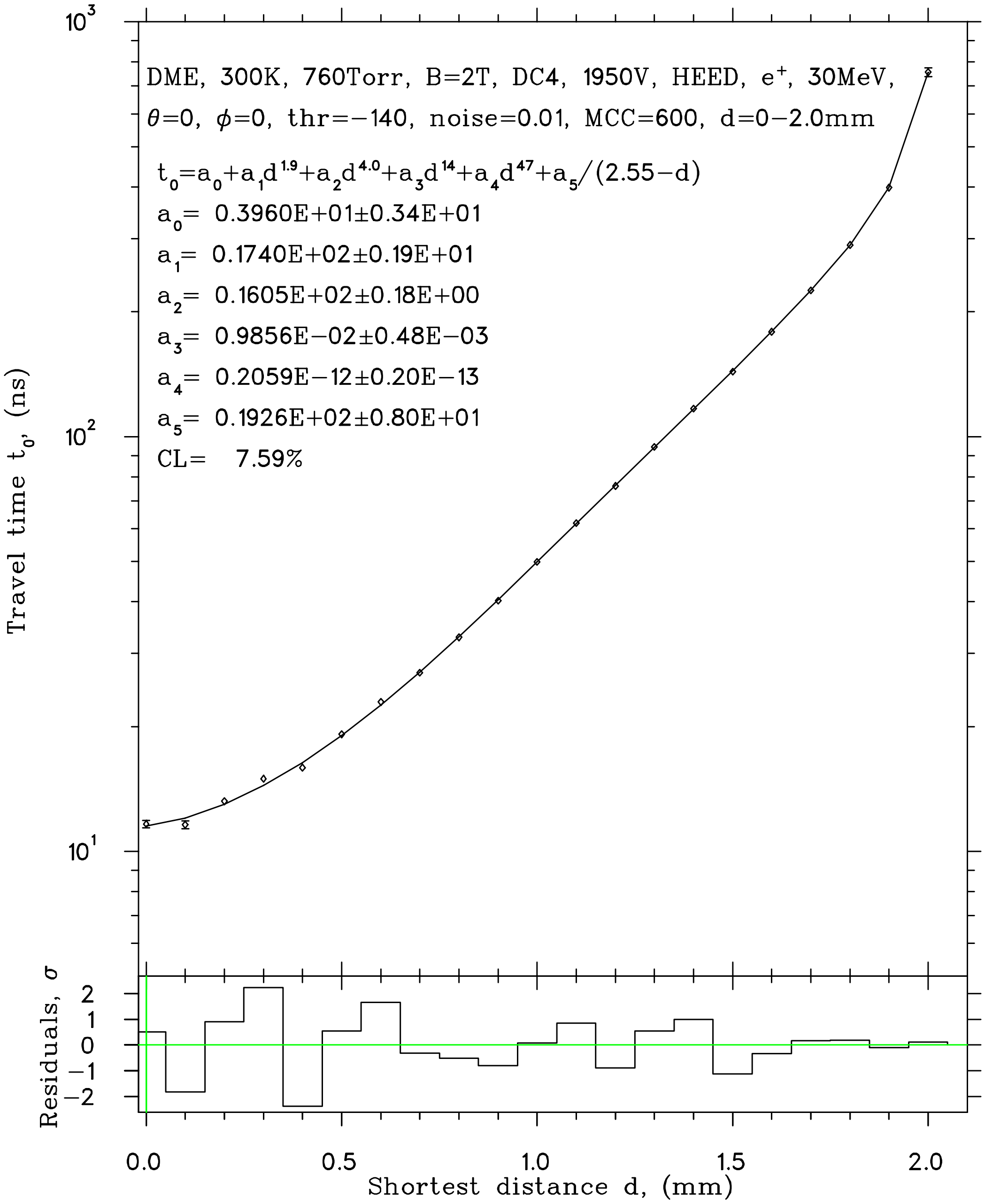

Figure 6: STR of DC4 at B=2T at $\theta = 0°$.

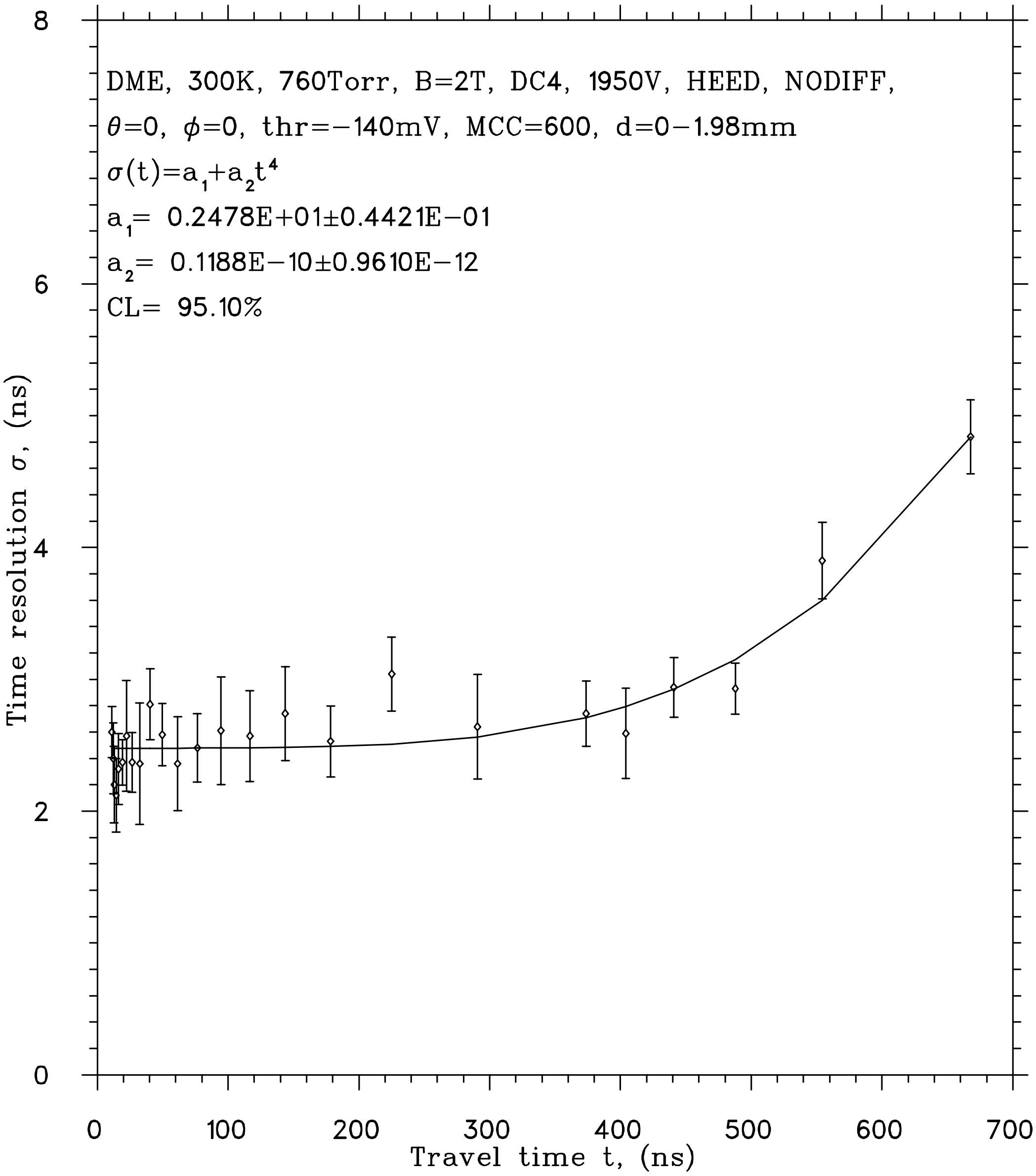

Figure 7: Time spread of a track in DC4 at B=2T at $\theta = 0°$. All processes are included except a diffusion.

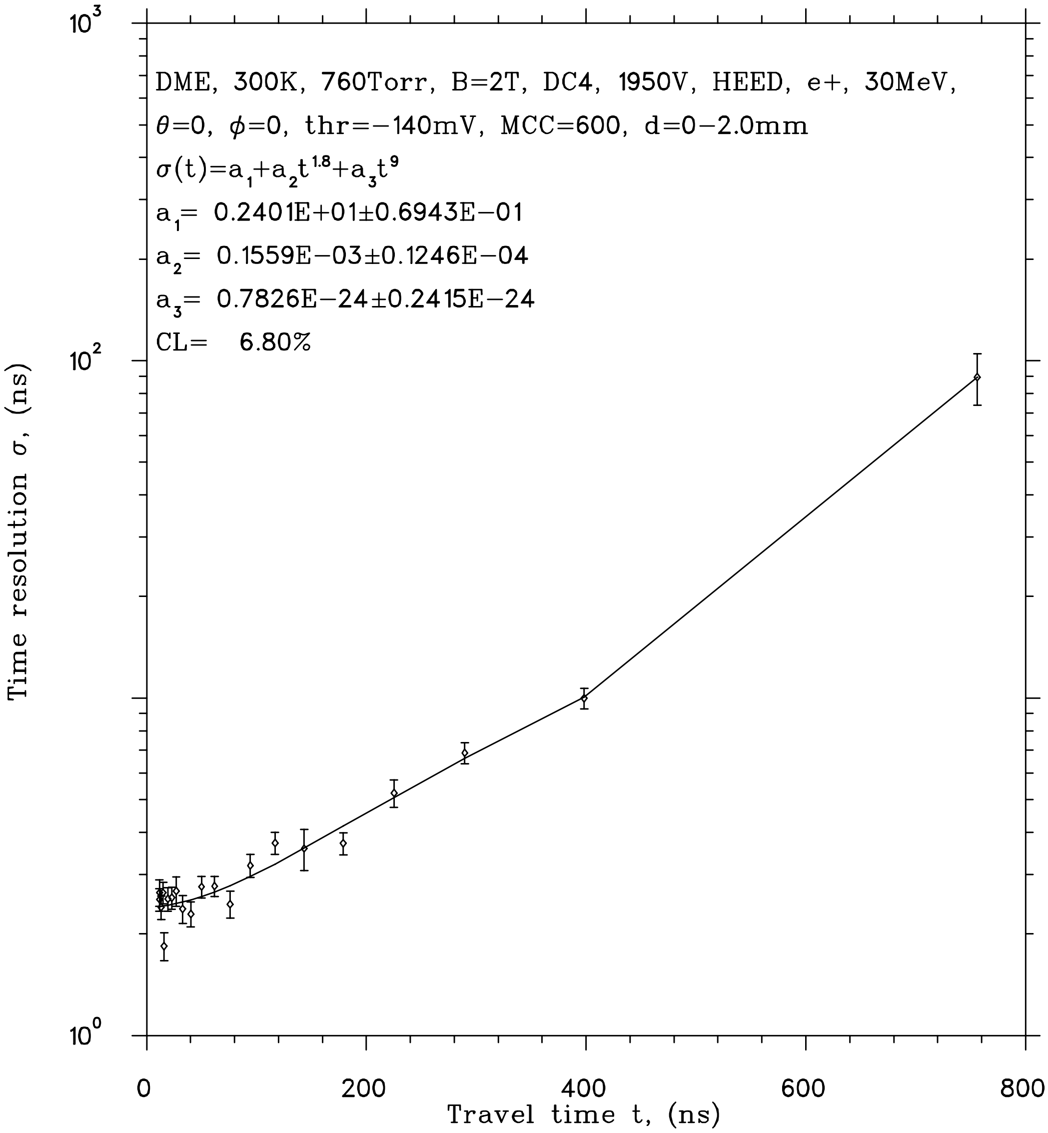

Figure 8: Time resolution of a track in DC4 at B=2T at $\theta = 0°$. All processes are included.